

Determining the Cost-Effectiveness of Treating Subclinical Ketosis in Dairy Cows

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Effectiveness of Treating Subclinical Ketosis in Dairy Cows

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ABSTRACT

Ketosis is a major metabolic disorder of dairy cattle in the United States, affecting an estimated 40% of all lactations in the industry (Geishauser et al., 2001). There are various viewpoints on whether it is cost effective to treat subclinical cases of ketosis (SCK) with propylene glycol (PPG) and dextrose in comparison to treating animals that become clinically ketotic (McArt et al., 2011, 2013). For this trial, there was a control group and two treatment groups. Control cows had blood β -hydroxybutyrate (BHBA) concentrations <1.2 mM/L and did not receive treatment. Treatment 1 cows were deemed subclinically ketotic, defined by a blood BHBA of 1.2 to 2.9 mM/L and received 250 mL 50% dextrose solution intravenously and 300 mL PPG orally for 3 d. Treatment 2 cows also were subclinical (same criteria as Trt 1) but did not receive the PPG and dextrose. Cows with >2.9 mM/L BHBA were not enrolled in the trial. To determine treatment, blood was drawn from the tail vein/artery at 4 d in milk (DIM) and tested for BHBA using a Precision Xtra Meter. Blood non-esterified fatty acids (NEFA) concentrations and BCS (1= thin, 5=fat) were recorded -14 to -3 d pre-partum. Pre-partum NEFA concentrations were similar between Trt 1 and 2 but decreased for control (309, 293, and 243 μ Eq/mL, respectively). BHBA at 4 DIM was similar for Trt 1 and 2 but less for control (1.66, 1.70, and 0.70 mM/L, respectively), with a similar pattern at 11 DIM (1.29, 1.43, and 0.71 mM/L, respectively). BCS at 11 DIM was similar for Trt 1 and control cows (3.37 vs 3.34) but less for Trt 2 cows (3.29). Milk yield was similar for control and Trt 1 cows, but milk yield was lesser for Trt 2 cows compared to control cows. This increased milk production from Trt 1

versus Trt 2 on a daily basis equals \$0.40/day (\$20/cwt milk price). Since it cost the farm \$5.90 to treat each case of subclinical ketosis, the increased milk production would have to be sustained for 15 days to cover the cost of treatment. The increased milk yield is an average over 90 DIM, so the return over cost of treating subclinical ketosis was \$30.10/cow for this period (Trt 1 produced 81 kg more milk than Trt 2). These results lead us to reach the conclusion that it is cost-effective to treat subclinical ketosis in recently fresh dairy cows.

INTRODUCTION

Ketosis is a major metabolic disorder of dairy cattle in the United States, affecting an estimated 40% of all lactations in the industry between clinical and subclinical cases (Geishauser et al., 2001). Clinical ketosis is also known as hyperketonemia and is characterized by high levels of ketones in the blood and is often manifested as lethargic and anoerexic behavior in the peri-partum dairy cow (Xia et al, 2012). Subclinical ketosis is more difficult to monitor because it is not noticeable to the eye without a blood, milk, or urine test. Even though it is not outwardly noticeable, it is still estimated to cost the farmer \$78/case due to both the direct and indirect costs associated with it (Geishauser et al., 2001).

This common disorder is caused when the body is in a state of negative energy balance, usually immediately post calving, when the demand for glucose and energy increases immensely and the body starts to mobilize the body's fat stores. Fat mobilization releases NEFA into the blood, where they can be used as a fuel source for several tissues, including muscle and can also be used by the mammary gland for fat synthesis (Palmquist et al., 1969). A portion of the NEFA released from lipolysis will be removed from the blood by the liver and metabolized by one of three pathways to help make up for the negative energy balance experienced in early lactation

(Drackley and Anderson, 2006). The liver can completely oxidize these fatty acids for energy, it can partially oxidize them to produce ketones, or the fatty acids can be packaged back as triglycerides and then incorporated into lipoproteins to go back to the tissues, or stored in the liver (Allen et al., 2013). The three most common ketones produced by the partial oxidation of fatty acids in the liver include acetone (AC), acetoacetate (ACAC), and BHBA and these three can be used for energy by some tissues, such as the brain, skeletal muscle, and cardiac muscles. This pathway is extremely important in the glucose sparing processes of the body that are of importance during periods of fasting and negative energy balance. Hepatic oxidation of fats, however, is believed to suppress appetite and reduce dry matter intake by inducing satiety (Allen et al., 2013). Depressing dry matter intake further confounds the original negative energy balance (NEB) issue and can send these animals on a downward trajectory if they are not treated.

It has been shown that ketosis and NEB also have negative consequences on reproduction and immune function (Esposito et al., 2014). When the body loses control of the level of ketones in the blood, the high concentrations will lead to weight loss, lethargy, suppressed appetite and often a sweet smelling breath (McArt et al., 2013). It is generally accepted that clinical ketosis occurs when blood BHBA levels reach >3.0 mM/L. Subclinical ketosis is often defined as blood BHBA concentrations of >1.2 mMol/L and <3.0 mMol/L and is considered to have a cost of \$78/case (Geishauser et al., 2001). These animals show no “clinical” signs but have been shown to be predisposed to decreased milk production, reduced reproductive efficiency, and at risk for other metabolic diseases. Studies done at Cornell University (McArt et al., 2011) have shown that propylene glycol has merit as a treatment for subclinical ketosis, but research done at the University of Minnesota (Carrier et al., 2006) revealed that a combination of treatments

(propylene glycol, dextrose, dexamethasone, and niacin) is not always cost effective in the treatment of subclinical ketosis.

The dairy farm used in this study had 3300 milk cows, and after reviewing the current research and expert opinions on treating subclinical ketosis, they were interested in determining the cost effectiveness of their current protocol. At the time of the study, the farm was using a combination treatment of 250 mL of 50% dextrose solution IV and 300 mL PPG orally to treat any cows with blood BHBA concentrations >1.2 mM/L. The purpose of this trial was to determine the cost effectiveness of treating for subclinical ketosis in Holstein dairy cows. We hypothesized that prepartum NEFA would be higher for cows that experienced subclinical ketosis after parturition than control cows. In addition, we expected that control cows and treated cows with subclinical ketosis would have higher milk yield than untreated cows.

METHODS

Blood samples were drawn from the tail vein/artery and body condition scores (1= thin, 5=fat) were taken on multiparous cows at -14 to -3 d pre-partum. The samples were centrifuged, the serum was pipetted off, and it was frozen until after the trial, when NEFA assays were conducted using a HR Series NEFA-HR (2) kit from Wako Diagnostics (Mountain View, CA). Cows were then enrolled into a treatment group at 4 DIM (4 d post-calving) when they received a health check that was consistent with on-farm protocols. There was a control and two treatment groups for this trial. Control cows (n=165) were multiparous, had <1.2 mM/L BHBA, appeared free from disease, and did not receive treatment. Treatment 1 cows (Trt 1) (n=58) were multiparous, deemed subclinically ketotic, defined by a BHBA of 1.2 to 2.9 mM/L but appeared otherwise healthy, and received 250 mL 50% dextrose solution intravenously on day 1 and 300

mL PPG orally for 3 d. Treatment 2 cows (Trt 2) (n=60) also were multiparous, subclinically ketotic (same criteria as Trt 1) and appeared otherwise healthy but did not receive the PPG and dextrose. Cows with >2.9 mM/L BHBA or any other diseases identified by the health check were not enrolled in the trial. Diseases and health issues that kept animals out of the trial at 4 DIM included lameness, mastitis, metritis with a fever, milk fever, and displaced abomasum. To determine treatment, blood was drawn from the tail vein/artery at 4 DIM and tested for BHBA concentration using a Precision Xtra Meter (Abbott Laboratories, Chicago, IL), and if BHBA was in the appropriate range and the cows fit the other health criteria, they were placed randomly into treatment 1 or 2 using the RAND function of Microsoft Excel. At 11 DIM, a second BHBA concentration was recorded as well as a BCS taken again and any animal with a BHBA >1.2 mM/L was treated with dextrose and PPG. If any animal's appearance warranted a health check, blood was drawn and checked for BHBA concentrations, a BCS was taken, and if the BHBA concentration was >1.2 mM/L BHBA, the animal was treated with dextrose and PPG regardless of the treatment group in which they were enrolled at 4 DIM. If a cow was re-checked after 6 DIM (end of medication with PPG) but before 11 DIM, the cow had a second BHBA analysis and a BCS was assigned at the time of the second bleeding, so they did not get scored on 11 DIM. Animals were followed for 90 DIM for recording of milk weights. Health events, including mastitis, lameness, and displaced abomasum, were recorded as well. BCS were taken at first breeding and reproduction data, including DIM at first breeding, were collected from Dairy Comp 305 (Valley Ag Software, Tulare, CA). Data were analyzed using the GLM procedure of SAS (SAS Institute, Inc., Cary, NC). Significance was declared at $P < 0.05$ and trends at $P < 0.10$.

Expenses associated with treating subclinical ketosis were obtained from the farm records and included labor, PPG, and dextrose. The costs of the Precision Xtra meter and test strips were not included because every cow gets checked at 4 DIM, as per the on-farm protocol. Labor cost of \$13.00/hr was used. The price of the increased yield of milk was calculated using the average price of milk over the time the trial was conducted (\$20/cwt).

RESULTS

Pre-partum NEFA concentrations were similar between Trt 1 and Trt 2 but less for control (316, 299, and 240 $\mu\text{Eq/mL}$, respectively; Table 1). BCS for the three groups pre-partum were 3.47 for control cows, 3.62 for Trt 1, and 3.59 for Trt 2 with control cows having a lower BCS. BHBA at 4 DIM was similar for Trt 1 and Trt 2 but less for control (1.66, 1.69, and 0.70 mM/L, respectively), with a similar pattern at 11 DIM (1.34, 1.46, and 0.69 mM/L, respectively). BCS at 11 DIM was similar for Trt 2 and control cows (3.31 vs 3.33) but increased for Trt 1 cows (3.45) (pre-partum BCS was used as a co-variant in this statistical analysis). Milk yield was similar for control and Trt 1 cows (42.7 and 42.1 kg/d, respectively) (Figure 1), but milk yield was decreased for Trt 2 cows (41.2 kg/d) compared to control cows. There was a trend ($P = 0.06$) for milk yield to be increased for Trt 1 versus Trt 2 cows. This increased milk production from Trt 1 versus Trt 2 on a daily basis equals \$0.40/d (\$20/cwt for milk price). Since it cost the farm \$5.90 to treat each case of subclinical ketosis (Table 2), the increased milk production would have to be sustained for 15 days to cover the cost of treatment. The increased milk yield is an average over 90 DIM, so the return over cost of treating subclinical ketosis is \$30.10/cow for this period (Trt 1 produced 81 kg more milk than Trt 2). Services per conception did not vary across Trt 1, Trt 2 and Control (2.15, 1.89, and 1.98, respectively).

Table 1. Non-esterified fatty acids (NEFA), serum β -hydroxybutyrate (BHBA), body condition score (BCS), milk yield and services per conception for control and treatment cows (DIM = days in milk).¹

Variable	Control	TRT 1	TRT 2	SE
Pre-partum NEFA, μ Eq/mL	240 ^b	316 ^a	299 ^a	19
Pre-partum BCS	3.47 ^b	3.62 ^a	3.59 ^a	0.03
4 DIM BHBA, mM/L	0.70 ^b	1.66 ^a	1.69 ^a	0.04
11 DIM BHBA, mM/L	0.69 ^b	1.34 ^a	1.46 ^a	0.10
11 DIM BCS	3.33 ^a	3.45 ^b	3.31 ^a	0.03
Milk, kg/d (wk 1-13)	42.7 ^{b,c}	42.1 ^{ab,c}	41.2 ^{a,d}	1.2
Services per conception	1.98	2.15	1.89	0.15

¹Control= <1.2 mM/L BHBA, TRT 1 = 1.2 to 2.9 mM/L BHBA received propylene glycol (PPG) and dextrose, and TRT 2 = 1.2 to 2.9 mM/L BHBA no PPG and dextrose; SE = standard error.

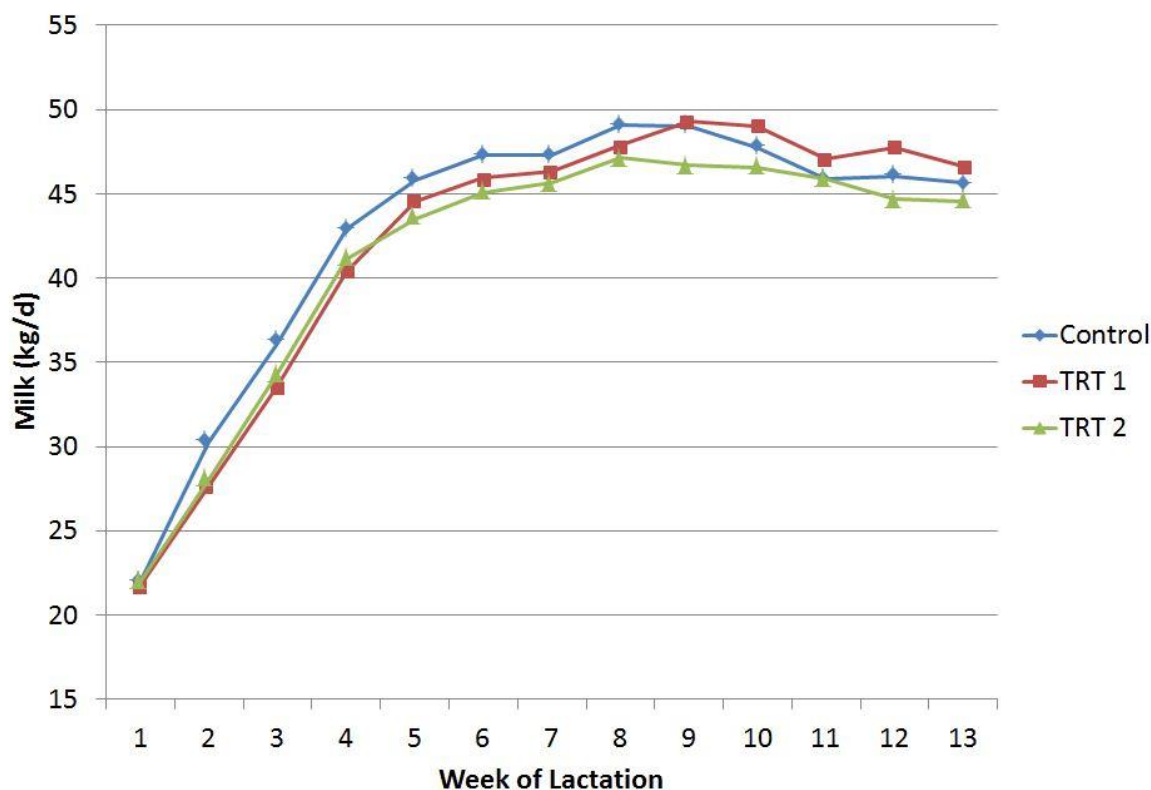
^{ab}Means in the same row differ ($P < 0.05$)

^{cd}Means in the same row tended to differ ($P = 0.06$)

Table 2. Cost of treatment per case of subclinical ketosis and net return on investment of increased milk yield.

Item Unit	\$/unit	dose/unit	\$/dose	dose/case	\$/case
Propylene Glycol (PPG)	\$900.00	690	\$0.81	3	(\$2.43)
Dextrose	\$2.36	2	\$1.18	1	(\$1.18)
Labor for PPG	\$13.00	40	\$0.33	3	(\$0.99)
Labor for Dextrose	\$13.00	10	\$1.30	1	(\$1.30)
Total Cost per Case					(\$5.90)
Revenue from Increased Milk Yield					\$36.00
Net Return on Investment per case					\$30.10

Figure 1. Milk yield for week of lactation by control and treatment cows.



DISCUSSION AND CONCLUSIONS

It has been shown in previous studies that elevated blood NEFA concentrations in close-up cows have a strong correlation to postpartum metabolic disorders, such as ketosis and DA. Elevated pre-partum NEFA concentrations are also associated with less milk production and decreased reproductive performance (Ospina et al., 2010; McArt et al., 2013). The results from the NEFA in our study was consistent with previous research as the two groups with increased BHBA concentration at 4 DIM both had increased NEFA concentrations pre-partum in comparison to the control, healthy cows. The blood BHBA concentrations of Trt 1 and Trt 2 were similar at 4 DIM, which is what we expected, and the control group was significantly

decreased. At 11 DIM, the two groups that started out with subclinical ketosis still had similar levels of BHBA in their blood and were decreased then at 4 DIM. However, the BHBA levels at 11 DIM were still, on average, in the subclinical range, although the standard error was greater than 4 DIM, suggesting a greater variation in levels at 11 DIM. These values still being above 1.2 mM/L begs the question of whether this treatment did as much good as was hoped. In the study by McArt et al. (2013), the subclinical cows were given PPG until they had BHBA concentrations below 1.2 mM/L and was not restricted to just 3 d.

The increased BCS at 11 DIM for Trt 1, about a tenth point greater, was as expected in comparison to Trt 2 given that Trt 1 were likely in a less NEB by receiving the IV of dextrose and three oral doses of PPG. Control animals had a BCS that was similar to Trt 2 at 11 DIM, and this is possibly because they started out with a decreased body condition and therefore were less predisposed to ketosis and also probably lost less condition. The less milk yield for Trt 2 compared to control cows was as expected, concurrent with previous research whereby subclinical cows produced less milk during the lactation. One possible explanation for this is Trt 2 cows likely consumed less dry matter while they were subclinically ketotic, which would result in less nutrients available for milk synthesis, even though they likely mobilized more adipose tissue in an attempt to support that milk yield. This decreased milk yield was consistent throughout the first 13 weeks of lactation (Figure 1). Milk yield for Trt 1 tended to be greater than for Trt 2 and even though the difference in milk yield only tended to be greater, it was very close to being statistically significant ($P = 0.06$) and with the animal numbers involved in this study and on the farm, this could still have large economic implications. The gain in milk yield returned \$30.10/cow for the 90-d period, showing some economic benefit to continuing to treat cows with subclinical ketosis. Although energy balance and milk yield appeared to favor Trt 1 in

comparison to Trt 2, services per conception were similar, which may have occurred because subclinical ketosis is less likely to impact reproduction efficiency than clinical ketosis. Another consideration is, at the time the data were examined, not all the animals of all the groups had been confirmed pregnant, so perhaps after all animals become pregnant, there may be some significance that arises. There is research indicating that animals with an elevated blood BHBA concentration in the first three weeks post-partum are less likely to become pregnant after their first insemination (Walsh et al., 2007), so we expect some differences to arise.

For the input costs and return on investment analyzed, the net return associated with medication and labor was favorable for the monitoring and treatment of subclinical ketosis with one day of intravenous dextrose and three days of oral PPG in this study.

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